Research Networks in New Zealand

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Abstract

Computers and communications are changing the nature of the research and development process. A loosely connected metanetwork spans the developed countries and enables researchers on opposite sides of the globe to work closely together sharing data, tools and conclusions.

This report reviews the current worldwide situation and describes the first steps towards a New Zealand research network. The principal issues affecting the further development of the network are discussed.

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Chapter 1

Introduction

Research and development are information intensive activities. New discoveries, innovative ideas, small steps forward are all accelerated when the research and development community has ready access to the most current information and where collaboration and cooperation are fostered. New Zealand has traditionally been disadvantaged by its remoteness and the time required to learn of new developments. Participation in worldwide research networks offers the opportunity to remove this handicap. Timely information is readily available and daily contact with colleagues from around the globe is feasible.

A computer network can provide the ability to communicate in an efficient and timely manner with geographically dispersed research colleagues. The sharing of ideas, data or even research projects themselves is made more feasible by eliminating the inconveniences of the telephone (such as cost and coordination) and the delays of the mail service. Such are the benefits that existing computer networks such as ARPANET and JANET have become indispensable tools for their user communities.

As well as communication with colleagues a network can also provide quick and convenient access to local and remote computing and information resources such as INFOS and the New Zealand Bibliographic Network. The advantages of having access to required information within hours instead of days are easy to imagine.

1.1 Motivation

In the second half of 1985 the New Zealand universities recognised the need for a national university network with international connections. Late that year they met in Wellington along with representatives of DSIR and MAF and agreed to establish such a network with links to DSIRnet and MAF. The Coloured Book Protocols used in the United Kingdom's Joint Academic Network (JANET) were chosen as the common protocol.

In early 1986 the Department of Computer Science at Victoria established connections between its UNIX[1] system and the Australian Computer Science Network (ACSNET) and the UUCP based network in North America. These network connections complement the Coloured Book connections. A mail relay among the various connections was implemented at Victoria during 1986.

Through 1986 we learned an enormous amount about research networks. We not only learned details of networking, problems of naming in international networks but at Victoria we quickly learned the importance of being a member of this international community.

It was our view that the ambition of a national university network was not sufficient. Instead we should be aiming for a research internet connecting academic, government and commercial organisations. Networks in Australia, the United States and the United Kingdom provide useful

[1] Unix is a registered trademark of A.T.&T.

models. To some extent the participation of DSIR and MAF from the start meant this was always a goal although never clearly stated. But what about other research institutions?

Much of this work has been undertaken by ad hoc groups with no official standing in the research community. As a result there is considerable difference in the knowledge of developments within the community. The study leading to this report was undertaken to:

- Determine the status of networking developments in New Zealand's research community as of the summer of 1986/87.
- Make that information available to the research community.
- Identify weaknesses in current developments to assist in planning for the next few years.

This report is the culmination of the study and addresses items 2 and 3. Readers who are new to research networks may find the entire report of value although chapter 4 is a small diversion into the technical world of protocols. Readers who are familiar with research networks and the current situation outside of New Zealand may wish to skip directly to chapters 6 and 7. These chapters summarise the current situation in New Zealand and discuss the issues that need to be addressed in the immediate future.

1.2 Methodology

Although we received support from Victoria University's Internal Research Committee and the Applied Mathematics Division of D.S.I.R. the resources and time were not available to conduct an exhaustive survey or to visit a large number of sites. We have not attempted to speak to every organisation in New Zealand which has a network or does research but we do believe we have a good general picture of the situation in New Zealand. Our goal was to develop a reasonably accurate picture of the state of networking in the NZ research community during the summer of 1986/87. We are aware that government departments that we have not spoken to have networks although we believe most of these networks are primarily for the support of the department's day to day activities rather than research and development.

During the course of our study discussions were held with academics in a variety of departments at Victoria University, with DSIR, BRANZ and MAF, and with NZBN and INFOS. The author was also able to attend a two day workshop held at Canterbury University to review the state of developments and to make plans for the coming year. As is befitting such a study we were also able to make use of international networks to gather information from overseas sources.

A number of individuals have been involved in the networking developments over the past two years. A number of these individuals also provided assistance compiling the information in the report. They are too many to name although in some cases where entire appendices are more or less due to someone credit is given.

Chapter 2

Network Services

2.1 Overview of Computer Networks

A computer network consists of a number of *hosts* connected by a potentially wide variety of different means. Hosts range from individual workstations to substantial computing resources. The hosts communicate using a set of protocols. Protocols typically define two things: the services provided by the protocol and the method used by different hosts to communicate using the protocols. The more technical aspects of protocols are discussed in Chapter 4.

Several different networks may be interconnected by one or more *gateways*. Such a connection is often termed an internet. The principal responsibility of a gateway is to translate from the protocols of one network to the protocols of another network. A gateway's ability to do this determines the services that are available over an internet.

Generally a user needs to know little of the technical details of a network. The user works at his or her host. Today the host is most likely connected to a *local area network* which is connected by a gateway to a *wide area network*. The wide area network may be a corporate or academic network. The wide area network will, in turn, be connected to one or more national networks. Finally national networks are interconnected to form a worldwide internet. This global internet has been referred to as 'Worldnet'[QH86] and 'WUNET'[Bra86].

The following section describes the services that may be available on a particular network. As a general rule the broader the geographic scope of the network the fewer the services which are available. This is because gateways tend to remove services rather than add them.

2.2 Network Services

A decade ago the cost of a network in the research environment was typically justified by resource sharing. Services such as file transfer, remote job entry and remote login were expected to increase the amount of information shared and the utilisation of expensive research equipment. Communication services in the form of electronic mail were seldom given any importance.

Today the most important service, and definitely the most pervasive, is electronic mail. All of the major networks support electronic communication among their users and the users of other networks.

2.2.1 Electronic Mail

Electronic mail is often promoted as offering advantages of both the traditional mail and telephone services. The communication is asynchronous, the receiver does not need to be available at the time that the sender is composing or sending the message, yet delivery is rapid compared with the post. In turn the receiver can respond to the message at his or her convenience.

Today there are two approaches to electronic mail. Most academic, research and corporate networks use a store and forward technique. The sender composes a message on his or her host and then *mails* the message. The message is transferred, sometimes by a tortuous route to the receiver's host. The receiver will usually be notified as soon as the message arrives, or the next time he or she logs in. The message may be read (and replied to if necessary) at the convenience of the receiver.

A number of commercial electronic mail services use a centralised approach. The user must login to the mail service's system to use the service. Messages are composed and sent in a similar manner, though mailing the message usually means placing it in a database to await collection. The receiver of the message will be notified when he or she next logs into the mail service. This contrasts with the store and forward approach in which the receiver's host is aware of the presence of undelivered mail.

Regardless of the approach taken to implementation, electronic mail services usually support mailing lists, manual and automatic forwarding of messages, courtesy and blind copies, and methods for storing and organising messages.

Charging for electronic mail is by volume. Within New Zealand the cost of a typical one page letter sent by electronic mail is $0.10, to Australia $0.60 and $1.20 to the rest of the world. Delivery times of electronic messages range from a matter of minutes to two or three days. The time is determined by the protocols in use and the manner in which the mail is delivered. Electronic mail is ideal for communications of modest length or where the delivery time is important.

2.2.2 File Transfer

With current technology electronic mail is limited to transferring text. Further, message lengths may be limited by some implementations. For researchers who wish to transfer data, graphic images and large files a file transfer protocol is needed.

File transfer allows a copy of a file to be sent from a user on one host to another user, on a different host and perhaps in a different country. The user initiating the transfer will need the rights to access the file. File transfer protocols will generally handle relatively simple sequential files without problem. More complex structured files may not be able to be transferred except between hosts with the same operating system. Gateways that support file transfer are not as prevalent as those that support mail. In general a user cannot expect to be able to transfer a file to any other host on *Worldnet*.

2.2.3 Remote Login

Remote login or remote access allows a user on one host to access another host as if he or she were directly connected to that host. This service is frequently used to access a database on some other host and interrogate it. It is also commonly used to access computing resources that are not available locally, for instance a supercomputer. Results obtained can be sent to a file on the users system by a combination of remote login and file transfer.

2.2.4 Miscellaneous Services

There are a number of services which are currently available on a small number of networks which, though not widely available, indicate what can be done. CSNET has a name service. This service allows CSNET users to locate individuals by doing keyword searches. The service may be used to find an individual's electronic mail address using his or her name as the search key. Alternatively it may be used to find a list of people with common research interests. ARPANET and BITNET offer similar services.

The internet composed of various UNIX networks supports a distributed bulletin board facility. Users post messages on the bulletin board in much the same way they would send an electronic mail message. The message is then transmitted to as many as 6500 UNIX systems around the world.

The bulletin board is structured into various discussion groups and supported by a sophisticated message reading system to assist users in finding messages of interest among the 2 megabytes of messages posted each day. ARPANET has a similar service.

2.2.5 Future Services

The popular media is full of comment on advances in communication services. Research networks can expect to be among the first to offer multi-media messages: the integration of text, voice and graphics. The advent of ISDN (Integrated Services Digital Network) on a large scale will greatly increase the bandwidth available for communication services. Services mentioned in the previous section which are not widely available will become more widely available and will be gatewayed between various networks.

Chapter 3

Benefits of Computer Networks

The previous chapter outlined the services provided by individual networks and worldwide internets. In this chapter I would like to enumerate how those services can enhance the research effort of New Zealand's research community. I should emphasise that these benefits are not simply what could happen. They are currently being enjoyed by many researchers in North America and Europe and by a small portion of researchers in New Zealand. These are observed benefits[LJF86].

3.1 Collaboration

All the services listed increase the opportunity for collaboration, especially among geographically dispersed researchers. This point is particularly important for New Zealand.

It is typical for a postal exchange between a researcher in New Zealand and a colleague in Europe or North America to take four weeks. With electronic mail this time can be reduced to at most a couple of days. With protocols such as the Coloured Book Suite which use X.25 circuits communication is limited more by the phasing of the working day than the speed of message delivery. This speed up is not simply a reduction in delivery time. It implies that meaningful exchanges can take place while a topic is still current.

File transfer may be used to exchange any item in machine readable form. Researchers may collaborate on the preparation of a manuscript, the analysis of some data or the implementation of a computer program.

3.2 Resource Sharing

New Zealand cannot afford many expensive research instruments. For instance it has been estimated that a population base of ten million is needed to support one supercomputer[Duf]. Many such instruments have computers as an integral part or are connected to computer systems at their local site. These instruments are then available to researchers with network connections to the specialised equipment.

Examples of resource sharing include remote access to either databases or supercomputers. The National Science Foundation in the United States is currently building a network with the primary purpose of making supercomputer access available to all scientists. A completely different example is the MOSIS chip fabrication facility supported by DARPA at the University of Southern California. Researchers use local computer aided design tools to produce the design of a chip. The design is then sent to MOSIS by file transfer and the chip returned by ordinary post.

A further example is the distribution of mathematical software by electronic mail[DG87]. Groups at Argonne National Laboratory and Bell Laboratories have constructed servers that respond to electronic mail messages. These servers enable a researcher to obtain the latest in numerical subroutines that are available. Together the servers respond to several thousand requests per month.

3.3 Dissemination of Information

It is quite common today for information to be rapidly disseminated electronically where the ability to do this is available. Typically this information is the type that would appear in technical reports. The information may appear a year or more later in a refereed journal. The author's department's limited experience with USENET's bulletin board supports this.

3.4 Easy Access to Information

Many users have already experienced the utility of having local information available on a personal workstation. Networks expand this to provide access to databases worldwide. At the moment most of these databases are bibliographic in nature but that is changing. I have already mentioned the database of implementations of numerical methods built by the numerical analysis community in the United States. Within New Zealand INFOS already offers statistical information about New Zealand. NZBN is planning to add databases of general interest to researchers in the social sciences during 1987.

3.5 Formation of Special Interest Groups

By using either electronic bulletin boards or mail groups researchers may form a special interest group. Messages posted by individuals go to all members of the group. The USENET News facility is essentially the union of a large number of such special interest groups. Where groups become very large it is common to introduce a moderator who audits the messages which are posted to the group.

Chapter 4

Network Protocols

While this report is not intended to be a technical paper on computer networks it is important to recognise the influence of protocols on research networks. In constructing a research network, or more appropriately an internet, we are interested in both the services that will be available and the community or communities we will be able to interact with. The protocols chosen will strongly influence both of these.

4.1 The OSI Model

The Open Systems Interconnection (OSI) Reference Model[DZ83] was developed as a framework for the development of international standards for network protocols and services. Figure 4.1 shows the traditional picture of the layered reference model. The layered approach was chosen to break the problem into manageable pieces. For each layer a Service Specification and a Protocol Specification are defined. The Service Specification defines the facilities provided to a user of the service and an interface to these facilities. The Protocol Specification defines the control information exchanged and the procedures used to interpret this information. The reference model has become a standard for the description of virtually any family of protocols.

Application. As the highest layer in the OSI Reference Model the Application Layer does not provide services to any other layer. It is concerned with the semantics of applications. A set of common procedures, the Common Application Service Elements, have been developed to assist in the development of applications.

Presentation. The primary purpose of the Presentation Layer is to provide independence to application processes from differences in data representations.

Session. The Session Layer provide the mechanisms for organising, structuring and controlling the interactions between application processes.

Transport. The Transport Layer provides transparent, end-to-end transfer of data. The goal is to relieve the higher layers of any concern with providing reliable data transfer.

Network. The Network Layer provides independence from the data transfer technology and independence from routing considerations. The Network Layer functions may be categorised into three sublayers:

Internet Routing Functions. This sublayer is concerned with routing among connected networks.

Subnetwork Convergence Functions. This sublayer defines the function necessary to enhance a particular subnetwork to allow data transfer across it consistent with the quality of service parameters of the Transport Layer.

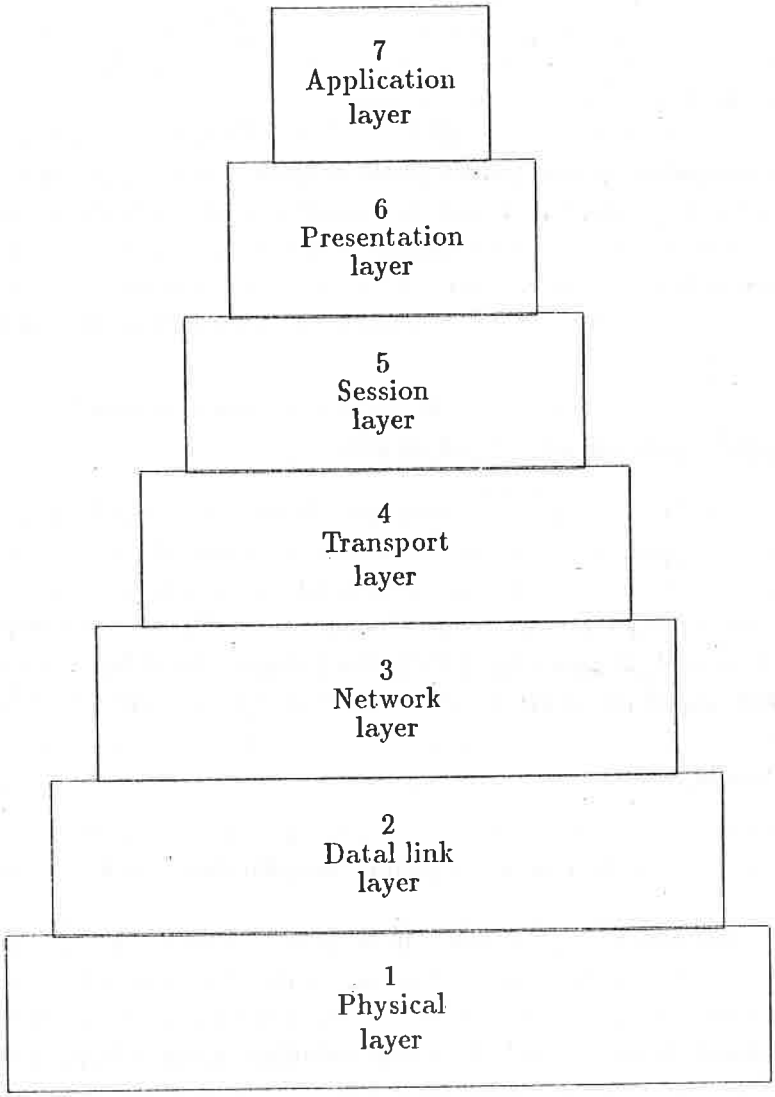

Figure 4.1: The OSI Reference Model

Subnetwork Access Functions. This sublayer uses the services of the Data Link Layer to provide an abstract subnetwork.

Data Link. The Data Link Layer provides the functional and procedural means to transfer data between adjacent network entities and to detect and possibly correct transmission errors.

Physical. The Physical Layer provides the mechanical, electrical, functional and procedural standards to access the physical medium.

For each layer the services provided to the layer above and the services required of the layer below are specified. The use of layers is designed to allow substitution of alternative protocols for particular technology without effecting the overall operation of the network. For example protocols for layers 1 to 3 for an ethernet (IEEE 802.3) are different than for a public packet switched network (X.25). However they both provide the same services to the transport layer and make it possible to use one transport layer to connect a host on the ethernet with a host on the packet network.

This example demonstrates the importance of the transport or internetwork layer. This layer is responsible for end-to-end connections between hosts and hides the technology and even the number and variety of networks involved in establishing the connection. The network services mentioned earlier are all implemented in the higher layers of the relevant protocols.

For this reason we will concentrate on the aspects of layers 4 through 7 of the three protocol suites under consideration.

4.2 Vendor Independent Protocols

When we consider a general research community we are considering a very diverse collection of activities. We can never expect anything other than a large collection of different systems from different vendors that must be connected in a meaningful way. For this reason we will concentrate our discussion on the three major vendor independent protocols. These are the protocols proposed by the International Standards Organisation (ISO), the Coloured Book Suite of Protocols developed in the United Kingdom and the Internet protocols developed for the ARPANET.

4.2.1 ISO Protocols

The ISO protocols follow the structure of the OSI reference model. At the time of writing some protocols and service definitions had been adopted as international standards. Others were still in draft standard form.

It is clear that the ISO family of protocols will be pervasive when they are generally available. Virtually all major networks are planning to migrate to the ISO protocols. Groups have formed to promote subsets of the ISO protocol suite in the manufacturing sector (MAP, Manufacturing and Automation Protocols[Kam86]) and the technical office sector (TOP, Technical and Office Protocols[Far86]). A key question is "How long will it be before these protocols are generally available?"

The MAP protocol suite is based on the ISO standards but does not require the implementation of many options in the full ISO protocols. At a meeting of the MAP Users Group held in 1986 it was suggested that the MAP protocols would not be generally available for five years[Cas86]. We can expect it to be longer before the full ISO protocols are available, although implementations of draft standards for certain applications will be available much sooner.

A complete list of the ISO protocols is given in Appendix A.

4.2.2 Coloured Book Protocols

The Coloured Book Protocol suite was developed in the United Kingdom in response to the need for a wide area network connecting academic and research sites. The suite was developed in the

late seventies and early eighties. At that time the corresponding international standards were not available. The Coloured Book Protocols were developed to use the existing low level international standard, X.25, and to implement the applications specified in the OSI model. Thus the UK community hoped the interim solution would ease eventual transition to international standards.

Because of the support given the Coloured Book effort in the United Kingdom implementations exist for a range of systems across a variety of vendors. A list of the available protocol implementations may be found in [HR86].

Network Independent Transport Service (Yellow Book)

The principle transport service is provided by the Yellow Book Transport Protocol which uses X.25. Implementations for a Cambridge Ring have been done and for Ethernet are under development.

Network Independent File Transfer Protocol (Blue Book)

This protocol specifies how files will be transferred between two systems. No attempt is made to translate between different binary data representations (or alternatively the Coloured Book Suite does not have a Presentation Layer). As a result binary data may only be transferred between homogeneous systems. Text can be translated between the major representations and text files may generally be transferred between any two systems.

Job Transfer and Manipulation Protocol (Red Book)

This protocol allows batch jobs to be submitted to remote systems for processing and the results to be returned to the originating host. The Blue Book File Transfer Protocol is used to effect both the submission of the job and return of the results.

JNT Mail Protocol (Grey Book)

The Grey Book protocol specifies the format of mail messages which are transferred as files using the Blue Book Protocol. The Mail Protocol is based on RFC 733 which specified the mail message syntax used on Arpanet before 1982. Arpanet now uses RFC 822 but the differences are minor and the Grey Book implementations are generally compatible with the Arpanet.

Character Terminal Protocols (Fawn Book)

This protocol specifies the use of an X.25 network to gain terminal access to a remote host.

Experience

The New Zealand Universities have now had over six months experience with the use of the Coloured Book Protocols, principally with the Yellow Book Transport Protocol and Grey Book Mail. It is worthwhile comparing our experience with expectations.

There is no doubt that the Coloured Book Protocols have allowed the Universities to construct a heterogeneous network. During 1986 these protocols were run on DEC and Prime equipment. Ironically nearly all the Universities have now moved to using DEC equipment for network communications negating one of the major advantages of the Coloured Book Protocols.

Problems have arisen with the use of these protocols. The Yellow Book Transport Protocol assumes the underlying X.25 network can establish an end-to-end connection. Neither Yellow Book or X.25 make any provision for internetworking and in the absence of X.25 local area networks on campuses it is impossible to reach machines not connected to the Post Office's PACNET. Further there is no provision for a name service in the definition of Yellow Book which requires each site to keep an up-to-date list of all other sites with which it may wish to communicate.

Because of the limitation mentioned above Grey Book Mail implementations are only capable of delivering mail to machines connected to PACNET. This in itself would not be a problem except that the available implementations do not provide any way to get at the addressing information on the messages' envelope. This makes the job of building a correct mail relay to interface with campus local area networks impossible. (A relay has been done at Victoria but it sometimes causes multiple copies of messages to be sent because of the lack of accurate information.)

4.2.3 The ARPANET Protocols

The ARPANET has developed over quite a period of years. Its network architecture has come to reflect the OSI Reference Model for the Physical through Transport Layers. At the higher levels each application in the ARPANET architecture tends to implement its own session and presentation functions[CC83].

The Internet Protocol (IP) is designed to support an end-to-end connection over a variety of networks. The supporting networks may be leased or phone lines, packet switched networks, various local area networks, radio and satellite links. The Transport and Control Protocol provides the functions of the transport layer. The protocols are frequently referred to together as TCP/IP, protocols which provide a transport function over a complex internet. In fact some applications use UDP, the Universal Datagram Protocol, where datagrams are more appropriate than virtual circuits.

Applications available over TCP/IP links include file transfer, mail and remote access.

The protocols and services in the DARPA family are defined by a set of Requests for Comment. A list of RFC's is given in Appendix B.

FTP

The File Transfer Protocol is used to identify, access and move files from one host to another. It provides for appropriate type conversion over a large range of hosts. It also includes provision for transparent transfer between hosts with identical systems.

TELNET

The TELNET protocol allows hosts to treat all remote terminals as if they were standard Network Virtual Terminals. Its primary benefit is to isolate hosts from requiring detailed knowledge of all remote terminals.

SMTP

The Simple Mail Transfer Protocol supports the transfer of electronic messages among arbitrary hosts in the ARPANET. SMTP has provision for a store and forward function as well as end-to-end delivery.

4.3 Summary

The major transport and application protocols of the ISO family, the Coloured Book family and the DARPA family are given in table 4.1.

Service	Service Definition		
	ISO	Coloured Book	ARPANET
Transport	ISO 8072 ISO 8073 DIS 8602	Yellow Book Transport Service	IP (RFC 791) TCP (RFC(793) UDP (RFC 768)
File Transfer	FTAM (DIS 8571)	Blue Book	FTP (RFC 959)
Remote Access	VTP (DIS 9040) (DIS 9041)	Fawn Book	TELNET (RFC 854)
Remote Job Management	JTM (DIS 8831) (DIS 8832)	Red Book	
Electronic Mail	MISD (DP 9595) MISP (DP 9596)	Grey Book	SMTP (RFC 821) (RFC 822)

Table 4.1: Network Services

Chapter 5

The World's Research Networks

5.1 The U.S. Internet

The United States has the longest continuous history of academic and research networks. Today a number of such networks, ARPANET, CSNET and NSFnet, are closely tied together. An electronic mail service joins all these networks into a single mail internet. The naming conventions are such that users of this service are not aware of the network used by the researcher to whom they are addressing mail. Additional services are offered by the individual networks.

5.1.1 ARPANET

The ARPANET was commenced in the late sixties under the sponsorship of the Advanced Research Projects Agency of the U.S. Department of Defence. It has served as a testbed for developments in computer networks ever since. It is now the largest single research network in the world, spread from Norway to Hawaii. ARPANET is still primarily a research network, providing resource sharing and electronic mail services.

The basic services provided by the ARPANET are electronic mail, file transfer and remote access as described with the TCP/IP protocols. These services are used to provide users with access to expensive resources such as the MOSIS chip fabrication facility and a number of supercomputers. The ARPANET also supports a form of electronic bulletin board based on mailing lists.

The ARPANET currently uses TCP/IP over a variety of connection medium. These have been primarily leased lines running a proprietary protocol however the network is gradually moving to an X.25 based packet switching network. The ARPANET is also committed to eventual migration to international standard protocols. There is currently a migration plan which calls for building ISO applications on top of an ISO Transport Layer interface implemented using TCP/IP and then gradually removing TCP/IP from service.

5.1.2 CSNET

CSNET is a computer science research network begun in 1980 under the sponsorship of the United States National Science Foundation. The principle goal was to provide advanced computer network services to the U.S. computer science research community. CSNET is actually a higher level network made up of several supporting networks, with varying costs and purposes.

The ARPANET is one of these supporting networks. CSNET users at ARPANET sites have all the services of ARPANET available to them. Alternatively sites may connect to CSNET using a public X.25 network. While the same services are available they tend to be less reliable and less efficient. Finally a large number of sites connect to CSNET using Phonenet. This service is inexpensive as it is limited to a 1200 bps connection to a central relay and only offers electronic mail service.

CSNET is currently experimenting with a new supporting network, Cypress. This network will used leased lines and provide a compromise between the expense of an X.25 network and the limited service of Phonenet.

In 1984 CSNET adopted a policy of allowing one site in a foreign country to operate a gateway for the academic institutions in that country to CSNET. The gateway is treated as a Phonenet site and the only service available to users outside the U.S. is electronic mail. The University of Waikato is setting up a gateway to CSNET for New Zealand. The gateway is expected to be fully available during 1987.

5.1.3 NSFnet

The following description of NSFnet is taken from [JLF*86].

> NSFnet will probably have the most impact on science of all networking activities in the United States at this time. Being based on new and existing networks, it will provide both high-speed access to supercomputers and communication between scientists in all disciplines throughout the nation. Although initially designed for supercomputer users to gain access to supercomputers and to communicate with each other, NSFnet is expected to be a general-purpose computer communications network for the whole academic research community and associated industrial researchers.

NSFnet networking activities were begun in 1984. As well as using networks such as ARPANET NSFnet will incorporate new networks with high speed links (1.544 Mbps). Initially NSFnet will use the TCP/IP ARPANET protocols. In coming years it will follow the ARPANET's migration to ISO protocols.

5.1.4 Specialised Networks

There are a number of small networks that serve highly specialised communities that are not currently part of the U.S. Internet. However these networks are certain to merge with NSFnet.

MFENET is sponsored by the U.S. Department of Energy. It provides access to supercomputers located at Lawrence Livermore National Laboratory and Florida State University. MFENET connects physics departments doing research in magnetic fusion energy or nuclear fusion. MFENET currently uses specialised protocols developed at Lawrence Livermore but is planning a migration to the TCP/IP protocols to be used by NSFnet.

HEPNET performs a similar role for High Energy Physics.

SPAN (the Space Physics Analysis Network) is used for research projects sponsored by NASA (the National Aeronautics and Space Administration) and ESA (the European Space Agency).

5.2 BITNET, NETNORTH and EARN

BITNET (Because It's Time NETwork) was started in 1981 connecting City University of New York and Yale University. In the intervening six years it has grown into four networks connecting academic sites in twenty one countries. As well as BITNET there is NETNORTH in Canada, EARN in Europe and Asianet in Japan.

All the networks are currently based on IBM's RSCS protocol. It offers electronic mail, messaging, and file transfer services. There is also a network information center which provides various databases which may be queried by network users. Emulations of the RSCS protocol have been

done for VAX/VMS[1] and UNIX systems. Sites join by paying for a leased line to a neighbor and expressing a willingness for subsequent new sites to connect to them.

Mail gateways exist between BITNET, the Internet and the UUCP network. Some IBM sites are unable to make use of these gateways because their local mailers are unable to handle the address syntax necessary to route a message through a gateway.

BITNET and NETNORTH are currently planning to migrate to the TCP/IP protocols and eventually to ISO standards. EARN is planing a direct transition to ISO standards. It appears there will be a period of time when these networks will use different protocols.

5.3 JANET

JANET (Joint Academic NETwork) has developed in the United Kingdom over a period of more than a decade although the current name was adopted in 1984. It currently connects between 1000 and 1500 hosts within the United Kingdom. JANET is funded by the Computer Board for Universities and Research Councils.

JANET services include electronic mail, file transfer, remote job entry and remote login. JANET uses the Coloured Book Protocols over a private X.25 long-haul network and X.25, Cambridge ring and Ethernet local area networks. Migration to ISO standards is planed for some time in the future.

Mail gateways exist between JANET and ARPANET, EUNET and EARN. All the gateways operate under various degrees of control in order to recover costs. This limits the use of JANET gateways by sites which are not part of JANET but which are using the Coloured Book Protocols. In some cases it also influences the way in which a U.K. host prefers to communicate with a site outside the U.K.

5.4 The Unix Networks

The UNIX networks are less of a research network than the other networks listed. However the networks have a total of over 10,000 sites including many universities and research labs as well as thousands of commercial sites. The news articles carried in the USENET newsgroups often involve discussions of current research projects. Thus the collection of UNIX networks are obviously a major resource for the researcher.

5.4.1 The UUCP Network

The UNIX network in North America is based on the UUCP protocols. There is no official administration and hence no real name for the network although it boasts 8000 to 9000 sites. New sites join by finding a nearby site that is willing to accept a phone call. Connection costs are minimal.

The only services widely available are electronic mail and the USENET News discussed below. The UUCP protocol is basically a file transfer protocol that is available over leased line, phone lines, X.25 networks and ethernet local area networks. The protocol only works between directly connected hosts. Thus the availability of a file transfer service is limited. Electronic mail is implemented using the UUCP protocol to transfer messages as files and augmented by programs to route the messages through the network.

5.4.2 ACSNET

The Australian Computer Science Network is somewhat inappropriately named. Started in 1979 as a network connecting computer science departments the network now has in excess of 300 hosts in various university departments, government labs and commercial organisations. Services offered include electronic mail, file transfer and the USENET News.

[1] VAX and VMS are trademarks of Digital Equipment Corporation.

ACSNET uses the SUN III protocols developed at the University of Sydney. These protocols are implemented for UNIX systems only although there has been some talk of implementing them for VAX/VMS.

5.4.3 EUNET and JUNET

The European UNIX Network was started in 1982. Unlike its North American counterpart the European network is organised by the European Unix Users' Group. The organisation allows the costs of electronic mail to be charged to the originating host and the cost of the USENET news groups to be shared among the 900 or so sites.

EUNET currently uses the UUCP protocols but has concluded an arrangement to distribute the SUN III protocols to EUNET sites. The degree to which these protocols will replace UUCP remains to be seen. Within Japan JUNET is currently funded by KDD, Japan's equivalent of N.Z. Telecoms Ltd.

JUNET (Japanese Unix Network) is run by a group of students at Tokyo University. It uses the UUCP protocols and currently has 160 hosts. JUNET has links to Unix networks in Europe, North America and Australia.

5.4.4 USENET

The USENET news network is a distributed bulletin board or conferencing system. Begun in 1980 it now reaches some 6000 sites on the various UNIX networks. The system is divided into a number of discussions called news groups. Some groups are moderated by volunteers, others allow anyone to post an article. A number of the news groups involve discussions of active research and new developments.

The distribution of articles is controlled by the individual hosts. In order for a site to subscribe to a particular newsgroup it must connect to another site which subscribes. Currently Victoria University picks up a limited number of newsgroups from Melbourne University. These groups are distributed to a small, but increasing, number of sites in New Zealand.

5.5 The EAN Networks

An implementation of the CCITT X.400 series of electronic mail protocols and the other supporting ISO protocols was developed at the University of British Columbia in 1983 to support a Canadian research network, CDNnet. CDNnet currently has about 65 hosts and the software, named EAN, has been turned over to a commercial organisation. Since 1984 the EAN software has been adopted by eight European countries to establish research networks.

5.6 Other Research Networks

Figure 5.1 is adapted from Quaterman and Hoskins and gives a list of networks, the number of connected hosts and the geographic spread of the network. There are a number of smaller research networks which are listed in the table although they have not been discussed. For information on these networks or more detail of the networks discussed see [QH86].

Network	Hosts	Coverage
ARPANET	2000	Principally North America with links to Europe.
CSNET	170	Principally North America with gateways in other countries.
NSFNET	65	U.S.A.
MFENET	120	U.S.A.
SPAN	100	U.S.A.
MAILNET	28	Electronic mail for U.S.A. and Europe. Now defunct?
JANET	900	United Kingdom
CDNnet	32	Canada
European EAN	33	Norway, Switzerland, Sweden, Germany, Ireland, Italy, Spain, Netherlands
COSAC	27	France
DFN	6	Germany
BITNET	850	U.S.A. and Mexico
NETNORTH	90	Canada
EARN	363	Europe
Asianet	7	Japan
UUCP	7,000+	North America
ACSNET	300	Australia
EUNET	900	Europe
JUNET	160	Japan
USENET News	2,500+	North America, Europe, Japan, Australia
SDN	100	Korean research network.

Table 5.1: The World's Research Networks

Chapter 6

New Zealand's Research Networks

The New Zealand research community began its networking efforts shortly after the establishment of Arpanet. In fact in was planned to link the B6700 at Victoria University to the Aloha network in Hawaii as early as 1973[FNN78]. The plans were dropped when the availability of a satellite link ended.

Today a number of New Zealand's research organisations have recognised the importance of computer networks to their own work. These organisations have well-developed networks. They have increasing workstation to staff ratios giving staff easier and more frequent access to network services. The interconnection of these networks is not as well established as overseas and has developed in a somewhat ad hoc manner. Connection to overseas networks is not universally available.

Many organisations have established or plan to establish links to information sources such as NZBN and INFOS, but the ability to communicate with users on many other networks is new and expanding. The rules that need to be known to access different networks still vary widely and are confusing for users.

This chapter begins with a brief history of networking efforts in the research community. This is followed by a review of New Zealand's principal research networks and information services. The current state of integration of these facilities is also discussed. The reader should be aware that this is a very dynamic area and developments may well have occurred since the time of writing.

6.1 Some History

In 1973 the New Zealand Universities were equipped with Burroughs B6700 systems. One of the motivations for purchasing the same system for each university was the benefits that would be gained from a network connecting the universities. During 1975 and 1976 Massey and Victoria Universities experimented with a network connection with the aim of sharing resources. This network was named Kiwinet[Hop76]. Victoria's B6700 was also connected to a HP2100 in the Applied Mathematics Division of D.S.I.R. (housed on the campus) and a third B6700 at the Reserve Bank. Each of these connections was independent of the others, for instance the staff of D.S.I.R. made use of Victoria's B6700 but were not able to reach Massey's.

In October 1976 the emphasis shifted to the design of a uniform general purpose network that would be able to link the machines on the Victoria campus and Massey's B6700. The project was named VICNET. Packet switching and the then new X.25 standard for interfacing to a packet switching network were chosen for the implementation. This project was extensively reported on at the Sixth New Zealand Computer Conference [Bow78] [HM78] [FNN78] [NBM78]. VICNET achieved modest success on the Victoria campus. Massey University was never successfully linked as funding for the line was lost.

In the meantime the Computer Research Section at the Physics and Engineering Laboratory of D.S.I.R. had begun the construction of a communications network for D.S.I.R. It started as a

small copy of what is now CSIRONET, using PDP[1] -11 hardware and CSIRO software. Its original purpose was to provide access to the IBM mainframes at the Cumberland and Vogel centres. By 1977 D.S.I.R. had developed a gateway with IBM 3270 emulation to give their users access to these machines. The gateway was extended to handle SNA in 1980, long before such products were available from vendors.

During the eighties D.S.I.R. computing has been dominated by DEC Vaxes and the communication network has been gradually upgraded to accommodate them. In 1985 an X.25 interface was added to allow DECnet[2] to share the bandwidth of the communication network with other existing network traffic.

In 1980 the universities' B6700 systems were replaced with a variety of equipment. The diversity of equipment and lack of a public computer network temporarily dampened enthusiasm for a university network. In 1984 Victoria established a campus network based on IBM's RSCS protocols used in BITNET. In 1985 a line was leased to Auckland University adding three Auckland University Computing Centre machines to the network.

The advent of a network between Auckland and Victoria Universities and the development of a public packet switched network motivated further moves in university networking. Two meetings were held during 1985 attended by representatives of the New Zealand universities, D.S.I.R. and M.A.F.. The second meeting held in November was called to coordinate the development of a national research network. That meeting was limited to one day and the only agreement that was reached was on a common protocol, the Coloured Book Suite. This decision was heavily influenced by the development of SPEARNET in Australia, although the Australians had not yet committed to the Coloured Book Protocols. The SPEARNET development is described below.

Today New Zealand is in the early stages of establishing its own internet to offer electronic mail services. This internet is currently based on DSIRnet, SPEARNET and a UNIX network. DSIRnet links all principal DSIR sites and is described in section 6.3. SPEARNET links all the universities except Canterbury[3]. SPEARNET is described in section 6.5. Finally Victoria University has established international mail connections to ACSNET and the North American Internet using UNIX protocols. A small number of other UNIX sites in New Zealand have also joined this network. Generally speaking Victoria operates a mail gateway service among the three principle networks thus implementing the internet.

In addition to hosts on these networks, some hosts which use VAX/VMS[4] and have connections to Telecom's PACNET use Digital's PSI mail to communicate with similar sites. Unfortunately this mail cannot generally be gatewayed about the internet. Many sites on the internet offer access to BRANZ, NZBN and INFOS information services though these are generally independent of the internet.

Figure 6.1 gives a conceptual map of the New Zealand internet.

6.2 Public Networks

The only public network available in New Zealand is Telecom's PACNET. PACNET is an X.25 network which offers a uniform cost structure throughout the country. There are several value added services. Telecom offers an electronic mail service named Starnet. Starnet is based on a central database for the storage of messages. Users are required to log into this database to receive notification of any mail. Starnet is interconnected with several similar mail services in other countries. Videotex services are also available and provide a source for dynamic information such as stock market movements.

[1] PDP is a trademark of Digital Equipment Corporation.
[2] DECnet is a trademark of Digital Equipment Corporation.
[3] Canterbury will have joined by the time this report appears.
[4] VAX and VMS are trademarks of Digital Equipment Corporation.

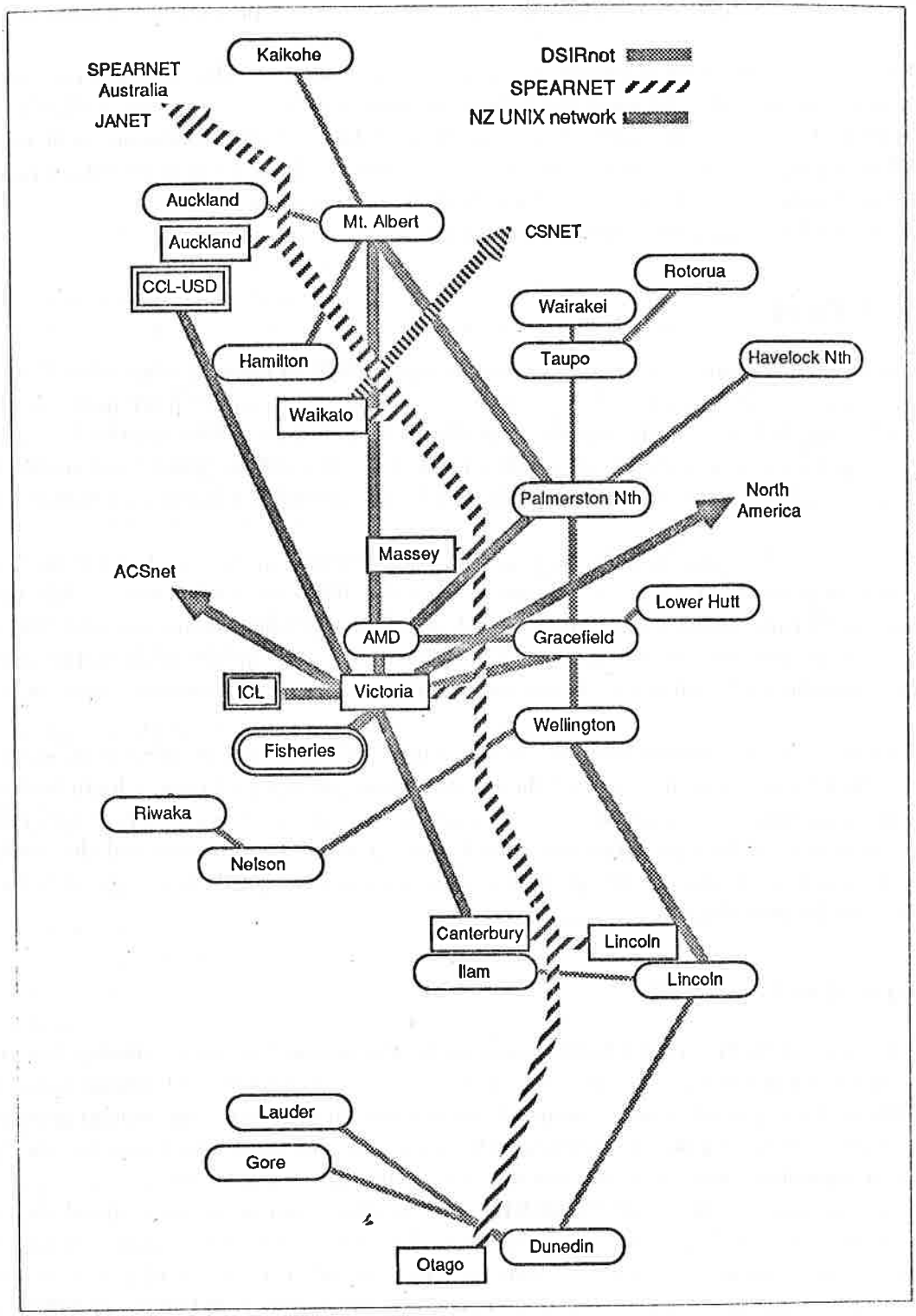

Figure 6.1: The New Zealand Electronic Mail Internet

6.3 DSIRnet

The development of DSIRnet was described above. Today the network connects numerous PDP-11 and VAX computers as well as several A.T.&T. 3B2 systems. DSIRnet currently has connections to the government's Cumberland and Vogel computing centres, INFOS and NZBN. The gateways to the IBM systems feature SNA emulation supporting remote login, remote job entry and remote printing.

D.S.I.R. is anxious to develop reliable communications with Australia, Europe and North America. They have obtained the Coloured Book Protocols from the United Kingdom and Digital's X.400 product. Both of these are currently on an experimental basis. During the summer of 1987 DSIRnet established a mail gateway to Victoria University which allows users on DSIRnet to exchange electronic mail with other researchers in New Zealand and overseas.

Details of DSIRnet may be found in Appendix C.

6.4 MAFnet

The Ministry of Agriculture and Fisheries operates a private X.25 network connecting DEC VAXes, Primes and a Pyramid. Since each system uses a different transport level protocol (DECnet, PRIMENET and TCP) the only service available is remote login. Sites currently connected to MAFnet are given in Appendix D. A number of smaller sites will be joining the network during 1987. Several local area networks exist within M.A.F. but are not yet integrated with the national network.

Users may use electronic mail by logging into the destination host and using the local mail facility. This requires that users be familiar with three different mail utilities. File transfer is achieved using Kermit between the source mainframe and a personal computer and then again to the destination mainframe. M.A.F. hope to significantly improve this situation in the near future. Possibilities include an X.400 network spanning different systems or movement to a single vendor network.

MAFnet has external connections to NZBN, Lincoln College, government computing centres and the UNIX network. The first four of these connections make use of remote login facilities. The government computing centres are used for computationally intensive work. The UNIX connection is between machines at Fisheries Research and Victoria University. International electronic mail is available to M.A.F. researchers who are able to login to the Fisheries UNIX system. A connection to INFOS is under consideration.

6.5 Spearnet

For the background to Spearnet I have depended on the account given in [HR86]. Spearnet was originally conceived in 1984 in Australia. Discussions were held with Digital Equipment Corporation during 1985 in the hopes of gaining financial support for the network. The official announcement of Spearnet came at a March 1986 seminar, though it was not until mid-1986 that the Spearnet management committee confirmed the use of the Coloured Book Protocols.

The pending announcement of SPEARNET and the likelihood of the adoption of the Coloured Book Protocols was instrumental in the universities, D.S.I.R. and M.A.F. selecting those protocols for a New Zealand network. This was done at the November 1985 meeting mentioned above. Representatives of the same organisations met again in Christchurch in February, 1987, to review progress and problems. To a large extent the development of SPEARNET within New Zealand during 1986 represents the development of university networking.

By February 1987 every university except Canterbury had implemented electronic mail based on the Grey Book mail protocol, Blue Book file transfer, Yellow Book transport service and PACNET. Massey's implementation was on their Primes, the other universities had implemented the protocols

on VAX/VMS systems. Canterbury had ordered a VAX/VMS system for the purpose of joining the network by mid 1987.

Although D.S.I.R. and M.A.F. attended the original meeting and agreed on the use of the Coloured Book Protocols neither had joined SPEARNET by February 1987. D.S.I.R. had an experimental implementation. M.A.F. had decided that the software for the Primes was too expensive for non-academic licenses. Thus SPEARNET in New Zealand has become a university network. The details of New Zealand's SPEARNET sites will be found in Appendix E.

The use of the Coloured Book Protocols gives the universities immediate access to other Coloured Book sites. This includes JANET and SPEARNET in Australia. Unfortunately the Australian arm of Spearnet has failed to develop in the same way as its New Zealand counterpart. The Australians already have a successful network, ACSNET, which performs many of the functions Spearnet is intended to do. A strong faction in Australia prefer to continue with ACSNET until the ISO standards are generally available. They argue that only at that point would it make sense to make the investment needed in starting a new network.

Access to networks which do not use the Coloured Book Protocols is currently limited. The problem stems from the implementations of the protocols rather than the actual choice of protocols. For example the Grey Book Mail system in use at Victoria is so tied to the file transfer system that it is not possible to capture a mail message while it is still in its *envelope*. To build a mail gateway it has been necessary to ask users to address mail through a phantom user. This user is in fact a process which inspects the actual mail message and forwards it to its destination. The need to build the gateway in this manner prevents the automatic construction of reply messages and makes it impossible to correctly handle messages addressed to a number of destinations.

Despite these problems a reasonable mail gateway does operate at Victoria between SPEARNET, DSIRnet, ACSNET and the UNIX network. Waikato is currently implementing a mail gateway between SPEARNET and its CSNET gateway.

6.6 The UNIX Network

The choice of the Coloured Book Protocols for the university network limited the international connections that would be available. To gain access to a larger international community Victoria University initiated connections between its UNIX system and the UNIX networks in Australia (Melbourne University) and North America (University of Calgary). These connections provide electronic mail service and access to USENET, the distributed electronic bulletin board system.

The beginnings of a UNIX based network now exist in New Zealand. In February 1987 sites in addition to Victoria were the Applied Mathematics Division of D.S.I.R. in Wellington and Auckland, Fisheries Research in Wellington, and ICL Computers in Wellington. By the middle of 1987 Waikato, Massey and Canterbury Universities are expected to join. The network is based on the UUCP protocols.

The principal use of the UNIX connections is to provide electronic mail access to Australia and North America and to make the Usenet News service widely available. The use of electronic mail has been greatly aided by the development of the gateway mentioned above. Interest in joining the UNIX network from the commercial sector has been generated by Usenet.

6.7 Information Services

Online information services have become increasingly important to today's researcher. In this section we describe three New Zealand based information services, the Department of Statistics INFOS, the New Zealand Bibliographic Network and the Building Research Associations service. The former two are well established. The latter is a good example of the type of information service that is likely to become more common place.

In addition to the New Zealand based information services many research institutions make use of international information services using PACNET to provide login access.

6.7.1 NZBN

The New Zealand Bibliographic Network is a division of the National Library. NZBN runs on IBM or IBM compatible equipment. There are currently 60 leased lines, almost all from libraries. These are heavy users who both retrieve information and update the database.

There are also about 100 users that access the database using PACNET. These users are more varied, e.g. banks, share brokers, etc., though most queries are still done by trained personnel. These users generally make inquiries, but there is very little updating of the database.

The nature of the information services offered by the National Library through NZBN will change significantly in the last half of 1987. With new equipment to be installed at mid-year NZBN will host a number of additional databases. These will include the D.S.I.R. Siris and Index NZ. The latter will index and provide abstracts of social science research literature and a good deal of popular literature within New Zealand. The number of NZBN users is expected to increase dramatically with the addition of the new databases. It is expected that many of the new users will not be professionally trained in the use of retrieval systems.

NZBN sees these services as complementing videotex. Videotex is best for volatile information (stock/commodity prices) while the NZBN databases will probably undergo fortnightly or monthly updating.

6.7.2 INFOS

The Department of Statistics Information Network for Official Statistics is a database held on a machine in Wellington. Users in Auckland and Christchurch may also gain access through Department of Statistics machines in those centres. Equipment is required to emulate IBM protocols. This limits access to leased lines and dial-up connections.

Users of INFOS may also make use of the SAS statistical package for processing raw data on the Department's system.

NZBN and INFOS are linked such that leased line users of one may access the other.

6.7.3 BRANZ

The Building Research Association of New Zealand maintains a research library for the building industry. In late 1986 a database with 20,000 entries was made available for the industry. At the start of 1987 there were 20 to 40 registered users. BRANZ provides a searching capability and, following the search, automatic requests for loan of a reference may be made.

Access to BRANZ's database is made using a simple ASCII terminal over Telecom's PACNET.

Chapter 7

Future Issues

Computer networks offer an opportunity for NZ researchers to become part of the worldwide research community. Interaction with colleagues can become immediate removing much of the lag that often occurs because of the distance between us and our colleagues. A loosely connected, ad hoc, research network currently exists in New Zealand. An effort is underway to build it into a robust resource for New Zealand's researchers. There is still much to do to insure that a smooth operation is available to all. In this section we consider a number of the outstanding issues that need to be considered.

7.1 Functionality

The only existing services generally available to the research community are electronic mail and remote login to the extent that it is available using PACNET. The latter service provides access to the information services listed in section 6.7.

It is clear that additional work is required to make the electronic mail service as effective as possible. Issues related to this aspect of development are discussed in section 7.1.2 below.

In chapter 2 we listed the various services that might be provided by a research network. These included file transfer, remote job entry and remote login in addition to electronic mail. The research community must decide which, if any, of these functions should be provided before the ISO protocol suites are generally available. The author believes it will be at least five years before these services are available in New Zealand.

To enhance the current services would likely require the adoption of a common protocol family within the research community. The impact of this is explored in the following section.

7.1.1 Protocols

We only have to look at overseas research networks to see that services beyond electronic mail are generally restricted to a single network, e.g. within ARPANET or within ACSNET. Thus we note that the first step toward additional services would be the adoption of a common protocol family.

Heterogeneity is a fact of life in research establishments. Different systems abound as researchers find systems suited to special needs. Thus any protocol family must be generally available over a range of systems to be considered for a research network. Today only two such families are available, the Coloured Book Protocols already in use in SPEARNET and the TCP/IP protocols which are dominant in North America.[1]

We should recall that a decision to adopt the Coloured Book Protocols was made at the November 1985 meeting. Unfortunately this decision has run into problems.

[1] The EAN implementation is available for a range of systems including most of those of interest in New Zealand, however, the only service offered is electronic mail.

- Neither D.S.I.R. nor M.A.F. have embraced the protocols. M.A.F. cited cost as an obstacle although their network is not nearly as well developed as DSIRnet. Clearly a decision to move from their current communications network to the Coloured Book Protocols would be a major decision for D.S.I.R.

- The Australians have failed to embrace the concept of Spearnet with the same enthusiasm as the New Zealand universities. The recent review of research networks in Australia[HR86] made no recommendation for the development of Spearnet, although it did acknowledge that a gateway for Grey Book mail would be needed. It is not clear whether this gateway is necessary because New Zealand has chosen the Coloured Book Protocols (along with JANET) or because the authors expect Spearnet to develop in Australia. It appears ACSNET is likely to continue to offer the best access to the Australian research community in the medium term.

- The current implementations of the Coloured Book Protocols have caused problems, especially in the area of creating gateways to local area networks. While an implementation of these protocols for ethernet based LANs is under development it is being developed by a commercial supplier and the limited size of the market may make the product expensive. The range of implementations is also quite limited.

These problems raise the question of dropping the Coloured Book Protocols in favour of TCP/IP. The author would have some preference for a shift to the TCP/IP protocols. Implementations are generally available 'off the shelf' and frequently at quite low costs, especially to educational institutions. The TCP/IP protocols are already in use on some campuses. There is also a migration plan from TCP/IP to ISO. We should remember that New Zealand researchers will want access to computing resources in North America that are not available in New Zealand. This will generally require the TCP/IP protocols.

However, the cost of changing protocols at this time can only be justified if

- the gateway problems with the Coloured Book implementations cannot be overcome, or

- additional services are required prior to the introduction of ISO protocols.

If we do not choose to offer services above and beyond electronic mail within New Zealand or internationally there is little benefit in changing protocols. Further to offer services beyond electronic mail would require that DSIRnet move to the agreed protocol, an expensive operation that probably cannot be justified before the availability of the ISO protocols.

> An effort should be made to reach agreement on the medium term goals for research networks in New Zealand. This agreement should be arrived at after carefully considering the costs and benefits of providing different levels of functionality across the network.

7.1.2 Electronic Mail

Assuming that the research community elects to restrict national networking to electronic mail over the medium term a substantial effort will be required to make this work smoothly. A good electronic mail service should be:

Reliable. It is only a short time from experimenting with electronic mail to becoming dependent on it.

Ubiquitous. It is not sufficient for some machine somewhere in the organisation to offer electronic mail. Local and company networks must support it and must have efficient and reliable gateways to national networks.

Consistent. Users will not tolerate the need to know different address syntax to reach different destinations. The world is adopting a domain approach to addressing electronic mail and it will be necessary for our mailers and our gateways to follow these developments.

The electronic mail service currently available should continue to be developed. Particular attention should be paid to the implementation of domain addressing and the construction of effective gateways among the various networks involved.

7.1.3 Additional Services

As well as the basic mail service additional enhancements should be considered. Networks such as CSNET and BITNET offer information services that respond to electronic mail. These services often help users find the electronic mail addresses of colleagues, or of strangers with similar interests. They also serve to keep users abreast of developments associated with the network. Journals encourage the electronic submission of articles. Software is distributed from on-line library services. The list of services and use of research networks will continue to grow in the immediate future.

An effort should be made to develop a number of network information services for the research community. These services could make local information available and could redistribute international information in a cost effective manner.

Creation of a Network Information Centre should be seriously considered to manage these services as well as the country's international gateways.

7.2 Administration and Funding

New Zealand does not have any national body with overall responsibility for research and development. This problem was highlighted in the Beattie Report[Be886]. This contrasts with the situation in other developed countries.

1. In the United States DARPA funds the ARPAnet and CSNET received five years of support from NSF during its development. BITNET has recevied substantial support from IBM.
2. JANET in Great Britian is funded by the Computer Board and Research Councils.
3. Japan's JUNET is funded by KDD International Telephone and Telegraph.

In the absence of such funding an ad hoc group has taken responsibility for establishing the priorities for the development of a research network. A major disadvantage of this approach is the lack of central funding for the development.

- The group has no operating budget. It is not able to make decisions based on priorities and then implement them. It can only make a list of projects that 'should be done' and hope that some group within the research community will undertake each project. Thus any progress is subject to the availability of 'spare' resources elsewhere.
- Without central funding each institution must take responsibility for its own expenses. Thus we find various universities setting up administrative procedures to charge other universities for the communications costs of gateways etc. While this may be in political favour at the moment it adds unnecessary costs to the development and discourages usage by the research community.

There does not appear to be any way to avoid these problems at this time. The current nature of research funding makes it difficult to obtain support for personnel, overheads etc. One possibility would be for the D.S.I.R. and the University Grants Committee to agree to jointly fund a group to administer and develop the network. In this case the majority of users (university and D.S.I.R.) would be supporting the remainder of the community.

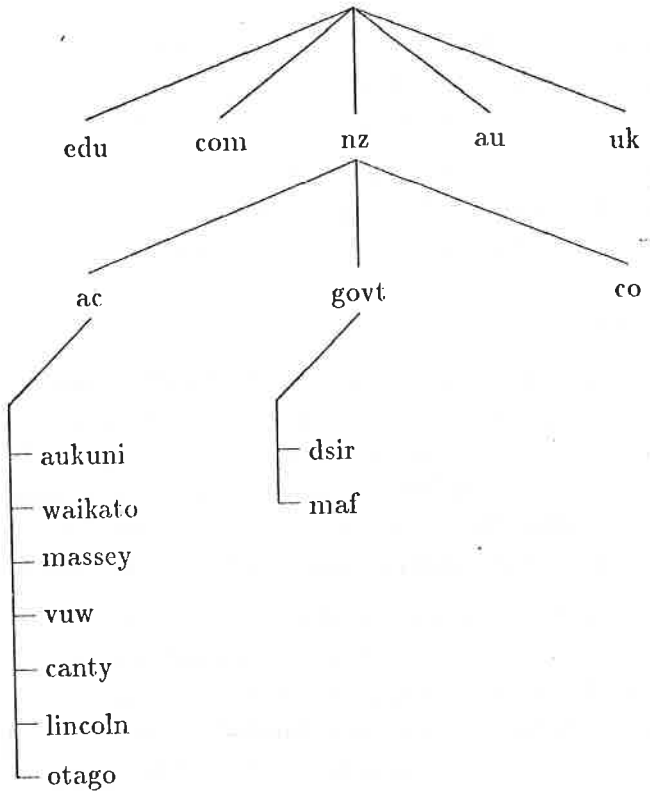

Figure 7.1: New Zealand's portion of the international domain tree.

Every effort should be made to find some basis for continual funding of New Zealand's research networks and the Network Information Centre recommended above.

7.3 Establishment of Domains

The world is moving to use of domains for addressing the recipients of electronic mail and naming remote resources. Domains operate much as the traditional addressing for the postal service or the ISD codes for the telephone service. The world is divided into a tree of domains. Each domain name encompasses all the names in its subtree. Figure 7.1 shows a small portion of the domain tree.

The International Standards Organisation has standard two letter abbreviations for each country. Countries other than the United States have adopted these abbreviations as the top level domain name for their country. (For historic reasons the United States uses several domains at the top level to indicate the general nature of organisations in each domain.)

The domain name for New Zealand is **nz**. Responsibility for managing the **nz** domain currently rests with the New Zealand Vice-Chancellor's Standing Committee on Computing. At the February 1987 meeting it was decided to follow international precedents and have three second level domains within New Zealand.

- The **ac** domain will cover all academic institutions, e.g. universities, polytechnics, etc. Responsibility for determining names of subdomains within **ac** currently rests with Victoria University.

  As an example the author's electronic mail address will become

  hine@comp.vuw.ac.nz

from any site in the world.

- The **govt** domain will cover all government departments. The Division of Information Technology of D.S.I.R. currently has responsibility for subdomains of **govt**.
- A third domain will be used to cover all commercial organisations. By convention the addresses of companies in the commercial domain will be

  company.co.nz

  Further subdomains may be used to refer to individual sites or departments within the company.

  At the moment no organisation has assumed responsibility for the commercial sector and a commercial domain is yet to be established.

The author feels it is important that the commercial sector become involved in the development of this network. Participation by commercial organisations as well as D.S.I.R. and the universities will foster collaboration in research activities.

> The development of support for domain naming and addressing should receive top priority as it will facilitate international connections and ease of use for the general research community.

Chapter 8

Conclusion

In this report I have tried to present a picture of the current state of New Zealand's research networks in comparison with the rest of the world. I have also attempted to highlight a number of important developments that require further work. In putting together this report I have been struck by the contrast between the potential benefits to New Zealand and the lack of consistent funding for the development of a national research network. While I have no doubt that the payoffs are so great that the network will evolve, I fear the evolution will be frustratingly slow because of a lack of committment of funds. This remains the biggest obstacle to the development of a comprehensive research network.

Appendix A

International Standard Protocols

The following list of standards from the International Standards Organisation are related to data communications and computer networks, particularly the OSI model. Thanks go to Phil Gross of Mitre Corporation and Robert Elz of the University of Melbourne who provided their lists and to Thomas Brunner of SRI International for extended descriptions.

A.1 Layer Independent Standards

A.1.1 OSI Reference Model

ISO 7498 Basic Reference Model. Defines common basis for coordination of standards, establishes architecture and functionality for a complete family of interfaces and protocols.

- Addendum 1. Connectionless Data Transmission. Defines changes to accomodate connectionless mode.
- Addendum 2. Security Architecture. General description of security services and layers in model where services may be provided.
- Addendum 3. Naming and Addressing. Provides architectural framework for assigning and managing names to objects within the OSI environment.
- Addendum 4. Management Framework.

N1037 Commentaries on OSI Reference Model.

A.1.2 Conventions

DTR 8509 Service Conventions.

A.1.3 Formal Description Techniques

DP 9074 Estelle.

DP 8807 LOTOS formal description technique.

A.1.4 Registration Authorities

N1252 Registration Authority.

A.1.5 Conformance Testing

DP xxxx/1 General Concepts.

DP xxxx/2 Abstract Test Suite Specification.

A.2 Upper Layer Standards

A.2.1 Application Layer

Common Application Service Elements

DIS 8649/1 CASE Introduction.

DIS 8649/2 CASE Association Control.

DIS 8649/3 Committment Concurrency Recovery Service.

DIS 8650/1 CASE Protocol Introduction.

DIS 8650/2 CASE Protocol for Association Control.

DIS 8650/3 Protocol for Committment Concurrency Recovery Service.

Job Transfer and Manipulation

DIS 8831 JTM Service.

DIS 8832 JTM Protocol.

Virtual Terminal Protocol

DIS 9040 VTP Service.

DIS 9041 VTP Protocol.

- Proposed Addendum 1. An extended facility.

File Transfer and Manipulation

DIS 8571/1 FTAM General Description.

DIS 8571/2 FTAM Virtual Filestore.

DIS 8571/3 FTAM Service.

DIS 8571/4 FTAM Protocol.

Other Applications

DIS 8505 Text Communication.

DIS 8883/1 Message Transfer: Model and Service Definition.

DIS 8883/2 Message Transfer: Protocol Specification.

DIS 8883/3 Message Transfer: Procedures for Distributed Operation.

DIS 9066 Text Communication, reliable transfer.

DP 9594/1 Directory Service Overview.

DP 9594/2 Information Framework.

DP 9594/3 Access & System Service.

DP 9594/4 Procotol for Distributed Operation.

DP 9594/5 Selected Attribute Types.

DP 9594/6 Selected Object Types.

DP 9594/7 Access & System Protocol.

DP 9595/1 MISD Overview.

DP 9595/2 MISD Service.

DP 9596/1 MIPS Overview.

DP 9596/2 MIPS Protocol.

A.2.2 Presentation

DIS 8822 Connection-Oriented Presentation Service Definition. Defines the externally visible service provided by the OSI Presentation Layer in terms of primitive actions and events, the parameter data, and relationship between and valid sequences of those actions.

DIS 8823 Connection-Oriented Presentation Protocol Specification. Specifies procedures for transfer of data and control information between presentation entities, means of selecting procedures, and structure and encoding of the protocol data units.

DIS 8824.2 ASN.1

DIS 8825.2 ASN.1 Encoding Rules.

A.2.3 Session

DIS 8326 Basic Connection Oriented Session Service Definition. Defines the Session Layer service provided to the Presentation Layer at the boundary between the Session and Presentation Layers.

- DIS 8326/1 Addendum 1. Session Symmetric Synchronization for the Session Service.

DIS 8327 Basic Connection Oriented Session Protocol Specification. Specifies protocol mechanisms for control and management of data flow between end systems.

- DIS 8327/1 Addendum 1. Session Symmetric Synchronization for the Session Protocol.

A.3 Lower Layer Standards

A.3.1 Transport Layer

ISO 8072 Transport Service Definition. Defines the service provided to the Session Layer at the boundary between the Session and Transport Layers.

- Addendum 1, Connectionless-mode Transmission. Applies principles of ISO 7498/DAD I for connectionless-mode.

ISO 8073 Connection Oriented Transport Protocol Specification. Protocol specification and common encoding mechanism for the five classes of procedures.

- Addendum 1, Network Connection Management Subprotocol.
- Addendum 2, Operation of Class 4 Over Connectionless Network Service.

DIS 8602 Connectionless-Mode Transport Service. Defines procedures to provide connectionless-mode transport service using either a network connectionless-mode service or connection-oriented service.

A.3.2 Network Layer

ISO 8348 Network Service Definition. Defines the connection-mode service provided by the Network Layer to the Transport Layer.

- Addendum 1, Connectionless Mode Transmission.
- Addendum 2, Network Layer Addressing.
- Proposed Draft Addendum 3, Additional Features.

DIS 8648 Internal Organization of the Network Layer. Defines sublayers of functionality within the Network Layer.

ISO 8473 Protocol for Providing the Connectionless-Mode Network Service. Defines functions and procedures, specifies format of protocol data units, defines underlying service needed.

- Draft Addendum 1, provision of the underlying service assumed by ISO 8473
- Proposed Draft Addendum 2, Formal Description.

DP 9542 ES-IS Routing with 8473.

ISO 8208 X.25 Packet Level Protocol For Data Terminal Equipment. Defines the protocol at the Network Layer for packet- mode DTEs to access a Public Data Network or for two directly connected packet mode DTEs to communicate.

- Proposed Draft Addendum 1, Alternative Logical Channel Number Assignment.
- Proposed Draft Addendum 2, Extensions for Private and Switched Use.

DP 8880 Specification of Protocols to Provide and Support the OSI Network Service.

- Part 1. General Principles and Conformance. Specifies conformance requirements for equipment providing the network service.
- Part 2. Use of X.25 for Connection-Oriented Serice.
- Part 3. Use of 8473 for Connectionless Service.

DP 9068 Provision of connectionless service using ISO 8208.

DIS 8881 Use of the X.25 Packet Level Protocol in Local Area Networks. Describes special considerations of operating over a LAN.

- Part 1. X.25 over LANs Using LLC1.
- Part 2. X.25 over LANs Using LLC2.

DP 8882 X.25 Conformance Testing.

- Part 1. General.
- Part 3. Packet Level.

DIS 8878 Use of X.25 to Provide the OSI Connection-Oriented Network Service. Defines the mapping of the connection-mode network service primitives and parameters to the protocol elements of the 1984 X.25 packet level protocol.

A.3.3 Data Link Layer

ISO 8886 Data Link Service Definition for Open Systems Interconnections. Defines services of the Data Link Layer to the Network Layer and interactions between them.

High-level Data Link Control

ISO 4335 High-level Data Link Control Procedures. Defines the operational modes, protocol elements, and control procedures of HDLC.

- Draft Addendum 1. Revises some of the text of ISO 4335.
- Draft Addendum 2. Enhancement of the XID Function Utility.

DIS 8208 X.25 Packet Level Protocol For Data Terminal Equipment. Defines the protocol at the Network Layer for packet- mode DTEs to access a Public Data Network or for two directly connected packet mode DTEs to communicate.

- Proposed Draft Addendum 1, Alternative Logical Channel Number Assignment.
- Propsed Draft Addendum 2, Extensions for Private and Switched Use.

DIS 8885 High-level Data Link Control Procedures. General purpose XID frame information field content and format. Defines the use of XID frames for identification.

DIS 7776 High-level Data Link Control Procedures. X.25 LAPB-Compatible DTE Data Link Layer Procedures. For packet mode DTEs to access a Public Data Network or for two directly connected packet mode DTEs to communicate.

ISO 7809 High-level Data Link Control Procedures - Consolidation of Classes of Procedures. Defines types and configurations of stations that use HDLC; defines HDLC classes of procedure, basic commands/responses.

DIS 8471 HDLC Balanced Classes of Procedures - Data Link Layer Address Resolution andNegotiation in Switched Environments. Defines procedure for determining Data Link Layer addresses using XID frames and all-station address where addresses are not known on a prior basis.

Local Area Network Protocols

DP 8802/1 General Introduction.

DP 8802/2 Logical Link Control.

DP 8802/3 Carrier Sense Multiple Access with Collison Detection.

DP 8802/4 Token-Passing Bus Access Method and Physical Layer Specification.

DP 8802/5Token Ring Access Method and Phsical Layer Specification.

DP 8802/7 Slotted Ring Access Method and Physical Layer Specification.

Appendix B

DARPA Protocol Specifications

The protocols used in the ARPANET are defined by a set of requests for comments. The following list gives the current RFC's. A number of important RFC's were gathered together in the DDN Protocol Handbook in 1985. RFCs which are marked with an asterisk (*) are not included in the 1985 DDN Protocol Handbook.

Thanks to Ole Jorgen Jacobsen of the ARPANET Network Information Center at SRI for the list.

B.1 Major RFCs

RFC-791	Internet Protocol (IP)
RFC-792	Internet Control Message Protocol (ICMP)
RFC-793	Transmission Control Protocol (TCP)
RFC-768	User Datagram Protocol (UDP)
RFC-854	Telnet Protocol (see also many Telnet Options in the RFC index)
RFC-959	File Transfer Protocol (FTP)
RFC-821	Simple Mail Transfer Protocol (SMTP)
RFC-822	Standard for the Format of ARPA Internet Text Messages
RFC-960	Assigned Numbers
RFC-961	Official ARPA Internet Protocols

B.2 Mail RFCs

RFC-821	Simple Mail Transfer Protocol (SMTP)
RFC-822	Standard for the Format of ARPA Internet Text Messages
RFC-886*	Proposed Standard for Message Header Munging
RFC-915*	Network Mail Path Services
RFC-934*	Proposed Standard for Message Encapsulation
RFC-937	Post Office Protocol Version 2
RFC-974*	Mail Routing and the Domain System
RFC-976*	UUCP Mail Interchange Format Standard
RFC-987*	Mapping between X.400 and RFC 822

B.3 Naming and Domain RFCs

RFC-799	Internet Name Domains
RFC-819*	Domain Naming Convention for Internet User Applications
RFC-882*	Domain Names - Concepts and Facilities
RFC-883	Domain Names - Implementation Specification
RFC-920*	Domain Requirements
RFC-921*	Domain Name System Implementation Schedule - Revised
RFC-973*	Domain System Changes and Observations
RFC-974*	Mail Routing and the Domain System
RFC-952	Internet Host Table Specification
RFC-953	Hostnames Server

B.4 Gateway RFCs

RFC-792	Internet Control Message Protocol (ICMP)
RFC-823	The DARPA Internet Gateway (GGP)
RFC-890*	Exterior Gateway Protocol Implementation Schedule
RFC-904	Exterior Gateway Protocol Formal Specification (EGP)
RFC-911*	EGP Gateway under Berkeley UNIX 4.2
RFC-975*	Autonomous Confederations
RFC-985*	Requirements for Internet Gateways – Draft

B.5 Local Area and Subnet RFCs

RFC-894	A Standard for the Transmission of IP Datagrams over Ethernet Networks
RFC-895	Standard for the Transmission of IP Datagrams over Experimental Ethernet Networks
RFC-948	Two Methods for the Transmission of IP Datagrams over IEEE 802.3 Networks
RFC-826	An Ethernet Address Resolution Protocol
RFC-903	A Reverse Address Resolution Protocol
RFC-925*	Multi-LAN Address Resolution Protocol
RFC-917*	Internet Subnets
RFC-940*	Toward an Internet Standard Scheme for Subnetting
RFC-950*	Internet Standard Subnetting Procedure
RFC-919*	Broadcasting Internet Datagrams
RFC-922*	Broadcasting Internet Datagrams in the Presence of Subnets
RFC-947*	Multi-network Broadcasting within the Internet
RFC-966*	Host Groups: A Multicast Extension to the Internet Protocol
RFC-988*	Host Extensions for IP Multicasting

B.6 Background RFCs

IEN-48	The Catenet Model for Internetworking
RFC-896*	Congestion Control in IP/TCP
RFC-970*	On Packet Switches with Infinite Storage
RFC-813	Window and Acknowledgement Strategy in TCP
RFC-814	Name, Addresses, Ports, and Routes
RFC-815	IP Datagram Reassembly Algorithms
RFC-816	Fault Isolation and Recovery
RFC-817	Modularity and Efficiency in Protocol Implementation
RFC-871*	A Perspective on the ARPANET Reference Model
RFC-872*	TCP-ON-A-LAN
RFC-873*	The Illusion of Vendor Support
RFC-874*	A Critique of X.25
RFC-980*	Protocol Documentation Order Information

B.7 Towards International Standards

RFC-905*	ISO Transport Protocol Specification
RFC-942*	Transport Protocols for Department of Defense Data Networks
RFC-939*	Executive Summary of the NRC Report on Transport Protocols for Department of Defense Data Networks
RFC-945*	DoD Statement on the NRC Report
RFC-983*	ISO Transport Services on Top of the TCP
RFC-941*	Addendum to the Network Service Definition Covering Network Layer Addressing
RFC-987*	Mapping between X.400 and RFC 822
RFC-926*	Protocol for Providing the Connectionless-Mode Network Services

Appendix C

DSIRnet Summary

C.1 Management

DSIRnet is managed by the Division of Information Technology of D.S.I.R. at Gracefield, Lower Hutt. The network manager is David Couch.

C.2 Sites

The following table gives a list of the VAX/VMS and UNIX sites on DSIRnet. These sites have may be reached by electronic mail from the developing New Zealand internet.

Host Name	Site
AKV, marcamd	Auckland (Mount Albert)
PMV, PNV, pnamd	Palmerston North
GRV, GMV, DBV	Gracefield
GIH	Division of Information Technoloty, Gracefield
GAP	Physics and Engineering Laboratory, Gracefield
LHN	Geological Survey, Lower Hutt
WNV, WMV, dsiramd	Wellington
HM0, HV0	D.S.I.R. Head Office, Wellington
V1G	Geophysics Division, Wellington
CHV	Lincoln

Other D.S.I.R. sites are on the communications network. Users at these sites have remote access to at least one VAX/VMS[1] system which they may use for receiving electronic mail. Sites in this category are:

Kaikohe	Auckland City	Huntly
Hamilton	Rotorua	Wairakei
Taupo	Havelock North	Lower Hutt
Taita	Nelson	Riwaka
Christchurch(Ilam)	Dunedin	Lauder
Gore		

[1] VAX and VMS are trademarks of Digital Equipment Corporation.

Appendix D

MAFnet Summary

D.1 Management

MAFnet is managed by the Computer Services Group. The network manager is Russell McIlraith.

D.2 Sites

The M.A.F. network is shown in figure D.1. The network consists of an X.25 backbone with switches in Auckland, Ruakura, Palmerston North, Wellington, Christchurch and Invermay. The following table gives a list of the Prime, VAX/VMS and UNIX sites on MAFnet. The only site currently accessible by electronic mail is nzfish.

Host Name	Site
Levin	Levin
FIB, FMD	Hume House, Wellington
WNCS, H0, ANODE	Wellington
IVY	Invermay
RUA	Ruakura
nzfish	Fisheries Research, Greta Pt.

Other MAF sites have access to the network through terminals or personal computers. Sites in this category are:

Kaikohe	Whangarei	Auckland
Tauranga	Hamilton	Rotorua
New Plymouth	Masterton	Palmerston North
Hastings	Napier	Gisborne
Wallaceville	Greta Point	Blenheim
Nelson	Greymouth	Lincoln College
Dunedin	Invercargill	Oamaru

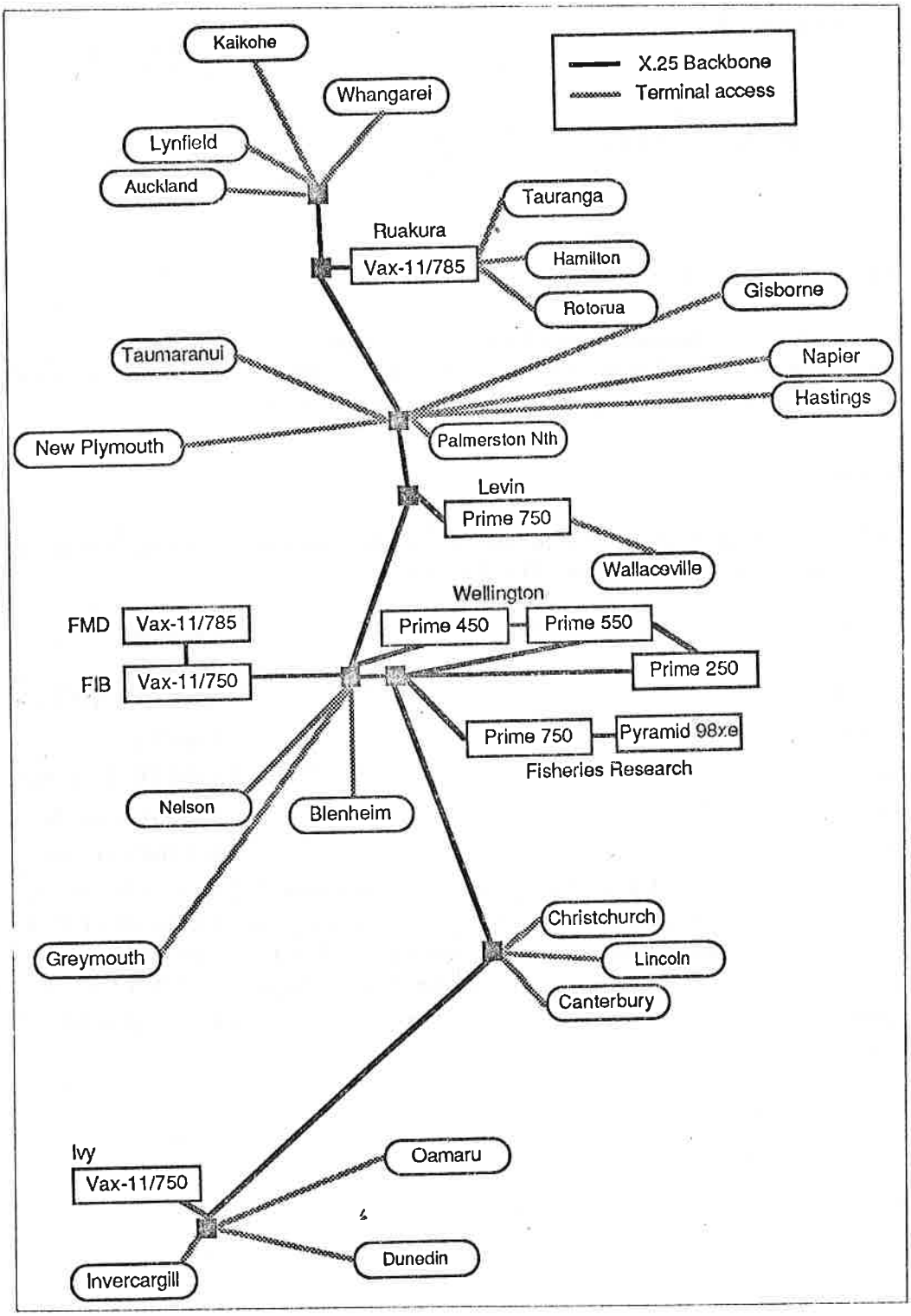

Figure D.1: The Ministry of Agriculture and Fisheries Network

Appendix E

Spearnet Summary

E.1 Management

SPEARNET planning is currently carried out by an ad hoc group that meets from time to time. To the extent that any official management exists it rests with the New Zealand Vice-Chancellors Standing Committee on Computing chaired by Dr. C.R. Boswell.

E.2 Sites

SPEARNET uses domain naming. The following table lists each university and the domains within the university that can be reached from SPEARNET.

University Department	Domain Name
Auckland	AUKUNI.AC.NZ
Canterbury	CANTY.AC.NZ
Lincoln	LINCOLN.AC.NZ
Massey	MASSEY.AC.NZ
Otago	OTAGO.AC.NZ
Victoria	RS1.VUW.AC.NZ
Computing Services Centre Research	VUW750.VUW.AC.NZ
Computing Services Centre Student Vax/750	ST0.VUW.AC.NZ
Computing Services Centre Student Vax Cluster	COMP.VUW.AC.NZ
Computer Science Dept.	
Waikato	WAIKATO.AC.NZ

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